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ENGINEERING EVALUATION / FACT SHEET

BACKGROUND INFORMATION

Application No.:	R13-2242B
Plant ID No.:	079-00105
Applicant:	Allied Waste Sycamore Landfill, LLC
Facility Name:	Sycamore Landfill
Location:	Hurricane
NAISC Code:	562212
Application Type:	Modification
Received Date:	December 27, 2011
Engineer Assigned:	Edward Andrews
Fee Amount:	$1000.00
Date Received:	December 29, 2011
Completeness Date:	January 27, 2012
Due Date:	April 26, 2012
Newspaper:	*The Putnam Standard*
Applicant Ad Date:	January 3, 2012
UTMs:	Easting: 410.4 km Northing: 4,250.3 km Zone: 17
Description:	This modification is for the replacement of the existing open flare with a smaller open flare.

DESCRIPTION OF MODIFICATION

Allied Waste Sycamore Landfill, LLC (Sycamore Landfill) is a municipal solid waste landfill. Sycamore Landfill operates under Title V Operating Permit R30-07900105-2010. Anaerobic bacteria decompose the emplaced waste. The primary by-products of decomposition are methane (~40 – 50%, typical), with the remainder gases of nitrogen, oxygen and trace amounts of non-methane organic compounds, commonly referred as landfill gas (LFG).

Sycamore Landfill currently employs an active gas collection and control system. The facility has not been required to install and operate a LFG control system, to meet the control requirements of New Source Performance Standards (NSPS) Subpart WWW. Gas collection wells are installed in a grid pattern about the landfill. The wells are connected to a common header system. A blower produces a vacuum on the well field. Collected gas is routed to the utility flare for LFG control.

LFG flow is variable, and depends on gas production in the landfill. The composition of the LFG varies, but the average Method 3 C values obtained on June 8, 2011, may be considered 'typical:' methane, 50.0%; carbon dioxide, 36.9%; oxygen, .4%; and nitrogen, 10.1%.

The existing flare was installed and placed into operation in 1998. For 2009, the monthly average flow rate of LFG to the flare was 262 scfm. This is very low for a flare with maximum rated flow rate of 2,225 scfm. Sycamore has elected to replace the existing flare with a John Zink open flare system. This new flare will have a maximum flow rating of 1,500 scfm. In addition, the gas collection will be driven by three blowers that will be powered by an electric motor that is controlled by a variable speed motor starter (controller). Each blower will have its own automatic block valve. These values only open once the programmable logic controller verifies pilot flame is present. In addition, the controller is programmed to shutdown the entire system if there is a main flame failure, automatic block valve failure, or flame arrester high temperature. The system is to be equipped with individual thermocouples for both the pilot and main flame.

SITE INSPECTION

On January 27, 2012, Mr. Gene Coccari, Small Business Assistance Group, and the writer conducted a site visit of the facility. Mr. Daniel Deborde, Environmental Manager of the Sycamore Landfill, was present during this visit. The writer explained that the Tier 2 Sampling conducted on November 12, 2009, indicated the landfill would exceed the 50 mega gram (Mg) per year threshold in 2011. Mr. Deborde provided the writer an additional copy of the Tier 2 Non-Methane Organic Compound Test Report conducted on June 8, 2011. Later, the writer discovered that the report was received by the DAQ on August 9, 2011. This report has not been reviewed or verified by the Compliance and Enforcement Section. This report indicates that the landfill would not exceed the 50 Mg per year trigger level until the year 2027.

The Sycamore Landfill had begun accepting solid waste in 1972. The landfill originally had a design capacity to accept up to 1.25 million mega grams of waste. The original part of the landfill is unlined and has been capped, which is about 8 acres. On September 9, 2005, the facility obtained permission to increase the capacity of the landfill up to 6.5 million mega grams.

Currently, the active gas collection system and flare controls LFG from Cells 1 and 2. The flare is located just west of the actual area of the landfill. The replacement flare will be located in nearly the exact same spot as the current flare. The nearest resident to this location was estimated to be just over 1,000 feet away, using Google Earth.

ESTIMATE OF EMISSIONS BY REVIEWING ENGINEER

The emission estimates in the application were based on the maximum flow rate (1,500 scfm) that the flare is designed to handle and the LFG gas having a heating value of 500 Btu per cubic feet of gas.

Other than sulfur dioxide, the secondary emissions from the flare were determined using equations and emission factors from Sections 2.4. “Municipal Solid Waste Landfills” and 13.5 “Industrial Flare” of AP-42.

Using the higher heating value of methane, the applicant predicted that the flare at its maximum flow rate could be releasing 45 MMBTU of heat energy per hour. This 50% methane content assumption is actually a regulatory default to be used when calculating NMOC emissions. The data from the June 8 2011, Tier 2 Testing indicates that the methane content is 50% for this landfill. Thus, one must use the 50% methane concentration assumption.

The consultant, Ms. Dana Fulk of Air Quality Specialist, Inc., prepared the proposed application for Sycamore Landfill. She also conducted the facility’s Tier 2 Testing this past summer. Ms. Fulk noted to the writer, from her experience in sampling and analyzing LFG, that hydrogen sulfide is under reported. She believed that the concentration of hydrogen sulfide in LFG could be as high as 100 ppmv. In addition, she believed that the default sulfur concentration listed in Chapter 2.4 of AP-42 to estimate sulfur dioxide is very low, which is 46.9 ppmv sulfur.

The approach used in the application is similar to the method outlined in Chapter 2.4. except that AP-42 provided a set default concentration for sulfur while the application listed each sulfur compound individually. This can be more easily illustrated in the following table.

Table #1 Sulfur Compound Concentrations

Influent Sulfur Compound	**Molecular Formula**	**Number of Sulfur Atoms**	**Concentration Listed in the Application (ppm)**	**Default Conc. listed in Table 2.4.-1* (ppmv)**	**Default Conc. listed in Table 2.4.2.* (ppmv)**
Carbon Disulfide	CS_2	2	2	0.147	0.58
Carbonyl Sulfide	CSO	1	2	0.122	0.49
Diethyl sulfide	$CH_3CH_2SCH_2CH_3$	1	-	0.086	-
Dimethyl Sulfide	C_2H_6S	1	4	5.66	7.82
Ethyl Mercaptan	C_2H6_S	1	4	0.198	2.28
Hydrogen Sulfide	H_2S	1	100	32	35.5
Methyl Mercaptan	CH_4S	1	24	13.7	2.49
Isopropyl Mercaptan	C_3H_8S	1	46	0.17	-
n-Propyl Mercaptan	$CH_3CH_2CH_2SH$	1	1	0.125	-
Dimethyl Disulfide	$C_2H_6S_2$	2	0.4	0.137	-

Tert-Butyl Mercaptan	$C_4H_{10}S$	1	-	0.325	-
Total Concentration of sulfur compounds by source			183.4	52.67	49.16

* Tables from the draft section of Chapter 2.4. of AP-42 dated October 2008.

The writer was not able to verify the proposed concentration of sulfur compounds with default valves published in the current version of Chapter 2.4. or the proposed draft version. The concentrations listed in the last column of Table #1 were from the proposed draft version of Chapter 2.4. The first column is the default concentrations of waste in place after 1992. The second column lists the default concentrations for facilities that had waste in place before 1992, which lists the exact same concentrations of the current version of Chapter 2.4.

When summed the default concentrations would equate to 101.5 ppm, which is very close to the concentration of hydrogen sulfide predicted by Sycamore's consultant. The collection system used at this landfill pulls LFG from cell 1 that has waste in place from 1972 to the mid 1990's and LFG from newer cells has waste in place after 1992. So the writer estimated the sulfur dioxide emission rate using the sum of the default concentrations. This yielded a sulfur dioxide rate of 1.5 pounds per hour and 6.7 tons per year. Using the defaulted sulfur concentration of 46.9 ppm as suggested in Chapter 2.4, the flare would have a potential sulfur dioxide emission rate of 0.74 pounds per hour and 3.3 tons per year. However, this rate would be significant less than the proposed rate of 2.77 pounds of sulfur dioxide per hour, which was based on the concentrations of the sulfur bounded compounds listed in the application.

Because there are regulatory standards related to sulfur dioxide that will be discussed in the following section of this evaluation, the writer has re-calculated the above mentioned sulfur dioxide rates in terms of grains of hydrogen sulfide per 100 cubic feet of LFG (carrier gas). In re-calculating of hydrogen sulfide, the writer treated the total sulfur concentration as hydrogen sulfide, which is presented in the following table.

Table #2 Sulfur Dioxide in terms of Hydrogen Sulfide			
Source	Proposed by Applicant (Conc. 183.	AP-42 Default Sulfur Conc. (46.9 ppm)	Assuming H_2S Conc of 101.5 ppm
Sulfur dioxide (SO_2) lb/hr	2.77	0.74	1.5
Hydrogen Sulfur (H_2S) grains/100 cubic ft. LFG	12.0	3.1	6.6

The Rule 10 allowable for combusting hydrogen sulfide is 50 grains per 100 cubic feet of carrier gas. Even using the applicant's proposed concentration, the source's hydrogen sulfide loading would only be 24% of the allowable. Thus, the applicant's approach in estimating the sulfur dioxide emissions from the proposed flare is considered appropriate for this case.

A copy of the calculations used in these estimates is attached to the end of this evaluation. Presented in the following table are potential secondary emissions from the flare. The hydrochloric acid estimated was based on the proposed chloride concentration of 74 ppmv from the draft section for Landfills having a majority of the waste in place after 1992.

Table #3 - Emissions from the Replacement Flare		
Pollutant	Emission Rates	
	lb/hr	TPY
Particulate Matter (PM)/PM less than 10 microns (PM_{10})/PM less than 2.5 microns ($PM_{2.5}$)	0.77	3.4
Sulfur Dioxide (SO_2)	2.77	12.1
Oxides of Nitrogen ($NO_{x)}$	3.06	13.4
Carbon Monoxide (CO)	16.7	73.0

Volatile Organic Compounds (VOCs)	0.22	1.0
Hydrochloric Acid (HCL)	0.63	2.8

Presented in the following table is permitted, proposed, and the net difference in annual emissions from the LFG flare.

Table #4 – Changes in Permitted Emission Limits				
Emission Point	Pollutant	Permitted under R13-2242A	Proposed	Net Difference
		TPY	TPY	TPY
Flare	Volatile Organic Compounds (VOC)	32.51	1.0	-31.51
	Carbon Monoxide (CO)	131.78	73.0	-58.78
	Oxides of Nitrogen (NOx)	7.03	13.4	6.37
	Sulfur Dioxide (SO2)	2.45	12.1	9.65
	Particulate Matter (PM/PM10)	2.99	3.4	0.41
	Hazardous Air Pollutants (HAPs)	2.98	3.47	0.49

When comparing the permitted emissions of the current flare to the proposed, one needs to realize the existing flare's emissions or PTE was based on LandGEM results using New Source Performance Standards Tier 1 values (default concentrations) instead of a site specific NMOC concentration. Second, the flow rate of LFG through the current flare was based on the predicted amount of LFG generated instead of the design flow rate of the flare. Third, the emission factors for NO_x and CO were from Chapter 2.4. instead of Chapter 13.5 of AP-42. In the proposed draft Chapter 2.4., the emission factors for LFG flares are reduced.

REGULATORY APPLICABILITY

45CSR6 To Prevent and Control Air Pollution From Combustion of Refuse

The purpose of this rule is to prevent and control air pollution from the combustion of refuse. The permittee has proposed to install an LFG-fired flare. This rule defines incineration as the destruction of combustible refuse by burning in a furnace designed for that purpose. The purpose of this flare is to destroy LFG through incineration. Thus, it meets this definition.

Per Section 4.1, this flare must meet the particulate matter limit by weight. The flare will have an allowable particulate matter emission rate of 19 pounds per hour (based on a maximum flow rate of LFG through the flare of 7,000 pounds of LFG per hour). The predicted particulate matter emission rate from the flare has been estimated to be 0.77 pounds per hour, which is significantly less than the allowable under this rule.

The flare is also subject to the 20% opacity limitation in section 4.3 of this rule. Typically, the incineration of most components contained in landfill gas usually produces little to no visible emissions when flared. The manufacturer, John Zink, notes that their ZEF flare destroying LGF should have a smokeless capacity of 100%. Thus, it is expect that this flare should be operated in the smokeless manner as the existing one.

45CSR10 To Prevent and Control Air Pollution From the Emission of Sulfur Oxides

The purpose of this rule is to prevent and control air pollution from the emissions of sulfur oxides. The proposed flare will emit sulfur oxide emissions, therefore is subject to this rule as combustion of a process gas stream.

This flare will be subject to the 50 grains per 100 cubic feet of carrier gas limit from 45CSR§10-5.1. Using the tabulated total reduced sulfur rate and the LFG flow rate, this writer calculated the maximum hydrogen sulfide concentration to be 12.0 grains per 100 cubic feet of LFG. Thus, this flare is capable of meeting this limit.

45CSR13 Permits for Construction, Modification, Relocation and Operation of Stationary sources of Air Pollutants, Notification Requirements, Administrative Updates, Temporary Permits, General Permits, and Procedures for Evaluation

The potential-to-emit from the proposed flare will exceed 6 pounds per hour and 10 tons per year for carbon monoxide, which is the trigger level of a source as defined in 45CSR§13-2.24. In addition, Rule 6 requires all incinerators to obtain a construction or modification permit regardless of size. Sycamore Landfill has proposed to install a smaller replacement flare, which is subject to Rule 6. Therefore, the facility is required to obtain a permit as required in 45CSR6-6.1.

The facility has met the applicable requirements of this rule by publishing a Class I Legal Advertisement in *The Putnam Standard* on January 3, 2012, paid the $1000.00 application fee, and submitted a complete permit application.

45CSR23 To Prevent and Control Emissions From Municipal Solid Waste Landfills

This rule establishes standards of performance for municipal solid waste landfills pursuant to Section 111 of the Federal Clean Air Act as amended in 1990. The purpose of this is to satisfy the State's requirement to develop a rule as mandated in 40 CFR Part 60, Subpart Cc. Overall, landfills constructed or modified before May 1991 with a design capacity of or greater than 2.5 million Mega grams (Mg) are subject to this rule. This landfill did not have a design capacity of this threshold or greater until 2005

In June 2011, the Sycamore Landfill conducted Tier II testing to determine a new site specific NMOC concentration value from the actual waste in place, which was 556 ppm. Using this new site specific NMOC concentration developed in 2011, the NMOC emission rate from the Sycamore Landfill was predicted to be 41.1 Mg in 2011 and not to exceed the 50 Mg trigger level until 2027. Therefore, Sycamore Landfill is not required to install and operate an active LFG collection and control system at this time, under this rule or Subpart WWW of 40 CFR Part 60.

45CSR30 Requirements for Operating Permits

This rule provides for the establishment of a comprehensive air quality permitting system consistent with the requirements of Title V of the Clean Air Act, and provides for a transition period prior to the implementation of the permitting system. Sycamore Landfill filed an amendment to the application, which included a request for a minor modification to their existing Title V operating permit, which would be required as result of this permitting action.

TOXICITY OF NON-CRITERIA REGULATED POLLUTANTS

The facility's potential to emit of hazardous air pollutants (HAPs) without controls is about 12.0 tons per year. With the 98% destruction efficiency of the flare, this potential is reduced down to 3.5 tons per year. Of this, 2.8 tons is hydrochloric acid.

Hydrochloric Acid

Hydrochloric acid is irritating and corrosive to any tissue it contacts. Brief exposure to low levels cause throat irritation. Exposure to higher levels can result in rapid breathing, narrowing of the bronchioles, blue coloring of skin, and accumulation of fluid in the lungs.

AIR QUALITY IMPACTS ANALYSIS

The writer deemed that an air dispersion modeling study or analysis was not necessary, because the proposed modification does not meet the definition of a major source as defined in 45CSR14.

MONITORING OF OPERATIONS

Monitoring for the gas collection system and flare should be limited to monitoring the gas flow rate, the pilot light and/or flare flame, and conducting visual emission checks.

Per the flare manufacturer and verified by this writer, this proposed flare is capable of at least a 98% destruction efficiency (DRE). During the review, it was determined that the flare should be able to achieve 98% DRE at the flare maximum flow rate of 1,500 scfm, which is based on the method outlined in U.S. EPA's Handbook – Control Technologies for Hazardous Air Pollutants. These calculations are attached to the end of this evaluation.

CHANGES TO PERMIT R13-2242A

Section 4.0 of Permit R13-2242A addresses the specific requirements of NSPS Subpart WWW. While Section 5.0 addresses the current flare as an emission unit at the facility. The requirements, as specified in Section 4.0, are adopted straight out of NSPS Subpart WWW. The main requirement is for a plan to monitor the actual landfill for the purposes of determining when the control requirement of NSPS Subpart WWW needs to be implemented. Further, NSPS Subpart WWW requires all affected sources subject to the subpart to obtain a Title V Operating Permits regardless of whether controls are to be applied or not. Second, landfills are normally constructed and operated without obtaining a Rule 13 permit even if the facility is subject to NSPS Subpart WWW. Landfills that have elected to install and operate a LFG collection system with an emission source (flare or other control device) are required to have a Rule 13 permit. In addition, the landfill is usually only required to obtain a Rule 13 permit as the result of constructing the flare. The writer believes that EPA realized that landfills across the country would not be required to obtain a permit under most States Minor Source Permitting Programs and was concerned that these States might overlook implementation of the NSPS standard. Thus, EPA addressed this potential issue by requiring all landfills that trigger the design capacity under NSPS Subpart WWW to obtain a Part 70 permit. Therefore, it is the opinion of the writer that incorporating this Section 4.0 with the NSPS Subpart WWW requirement is not necessary and it has not been transferred to the proposed draft permit. In lieu of the NSPS Subpart WWW conditions in Section 4.0 of Permit, the following language has been inserted on the second page of the permit.

"Allied Waste Sycamore Landfill, LLC as the owner and/or operator of the Sycamore Landfill will continue to conduct Tier II testing as allowed under 40 CFR Part 60, Subpart WWW to demonstrated that the facility's NMOC's are below the 50 Mg trigger level. By demonstrating that the NMOC emissions are below 50 Mg per year level, the active collection system and flare as permitted in this permit is not required to comply with the emission standard under 40 CFR Part 60, Subpart WWW. Thus, this active collection system with a flare and the destruction of methane is considered to be voluntary on the permittee part. This voluntary status will remain in effect until such time that the tier II testing indicates that facility NMOC emissions exceeds the limits as set forth in 40 CFR Part 60, Subpart WWW."

Section 5.0 of Permit R13-2242A contains the specific requirements for the flare and specific citations from Rule 6. The main problem with citations from Rule 6 is that these citations were created to prevent or limit emission from the reduction of size of solid materials (waste) through incineration. For landfills, the landfill is actually reducing the size of the solid waste through decomposition and the by-product of this decomposition is LFG. The flare is only incinerating the LFG and not the solid waste. The type of incineration was taken into consideration when incorporating citations from Rule 6 into this Rule 13 permit.

Presented in the following table is a list of conditions from Section 5.1 of Permit R13-2242A with noted changes.

Table # 5 - Changes to Section 5.1.

Condition No. in R13-2242A	**Condition No. in Draft Permit**	**Remarks**
5.1.1.	4.1.1.	Omitted the restriction to just Cells to include the entire landfill
5.1.2.	4.1.2.	Replaced alarm w/automatically closing blower blocking valves
5.1.3.	Omitted	See following discussion
5.1.4.	4.1.3.	Adjusted Emission Limits.
5.1.5.	4.1.5.	No changes
5.1.6.	4.1.6.	No changes
5.1.7.	Omitted	Not appropriate for this source (Source is not being permitted to burn or incinerate refuse.)
5.1.8.	4.1.8.	No changes
5.1.9.	Omitted	Not appropriate because the facility submitted application for the flare (45CSR6-6.1)
5.1.10.	5.1.9.	No changes

Condition 5.1.3. established an operation range of the exit velocity flare tip velocity) for the LFG. The purpose of this range is to ensure the flare can achieve a minimum destruction efficiency of 98%. This velocity range listed in Condition 5.1.3. is only good for flaring a effluent with a heating value of less than 300 Btu per standard cubic foot. For effluent with a heating valve greater than 300 Btu per standard cubic foot, EPA developed an equation that is a function of the heat content of the effluent. Using the range stated in the current permit, the proposed flare could be operated with a flow rate up to1,050 scfm, which restricts the operating range of the flare unnecessarily. The tip velocity at the maximum design flow rate is less than the maximum permitted as calculated using EPA's equation. (See attached calculations). There is a need to stipulate a maximum tip velocity since it is based on the maximum design of the proposed flare and Conditions 4.1.4. (Established annual flow rate limit) and 4.1.5. (Required a continuous flow monitor) ensures that the maximum design flow rate is not exceed.

RECOMMENDATION TO DIRECTOR

The information provided in the permit application indicates the proposed replacement flare will meet all the requirements of the application rules and regulations when operated in accordance to the permit application. Therefore, this writer recommends granting Allied Waste Sycamore Landfill, Inc. a Rule 13 modification permit for the construction of a replacement flare.

Edward S. Andrews, P.E.
Engineer

Date: February 29, 2012

This worksheet is for the flare proposed in application R13-2242B for the Sycamore Landfill. The formulas used are from Appendix C-5 of U.S. EPA Handbook: Control Technologies for Hazardous Air Pollutants. EPA/625/6-91/014.

The flare under review is a John Zink ZEF (open) flare, which is non-assisted elevated flare.

Provided Data:

1. $Q_e := 1500$ — Flow rate of the total LFG going to the flare, in units of scfm.

2. $T_e := 69$ — Emission Stream Temperature, degrees F.

3. $h_e := 500$ — Heat Content of the LFG stream, Btu/scf.

4. $D_{tip} := 10$ — Flare tip diameter, inches.

5. $T_{flg} := T_e$ — Temperature of the flare gas, degrees F.

Supplementary Fuel Requirements

Since the heat content of the stream going to the flare is greater than 200 Btu/scf, then no supplementary fuel is required.

$h_e = 500$ — Heat Content of the waste gas stream, Btu/scf.

Thus, no supplement fuel is required; or

$Q_f := 0$ — Flow rate of natural gas add to the waste gas stream, scfm

Flare Gas Flow and Heat Content

The flare gas flow rate is determined from the flow rates of the emission stream and natural gas using the following equation:

$Q_{flg} := Q_e + Q_f$ — Equation 4.4-2 on page 4-22 of the handbook, scfm.

$Q_{flg} = 1.5 \cdot 10^3$ — Maximum Flow rate of waste gas and natural gas going to the flare, scfm.

Flare Gas Exit Velocity and Destruction Efficiency

U.S. EPA's handbook offer several methods in order to calculated the maximum velocity based on a destruction efficiency of 98%. However, these methods are for non-assisted flares.

The information available on flare destruction efficiency as a function of exit velocity does not allow for a precise determination of this value. All that can be ascertained is whether the destruction efficiency is greater than or less than 98 percent, depending the exit velocity.

$$U_{flg} := \frac{\left(5.766 \cdot 10^{-3}\right) \cdot Q_{flg} \cdot \left(T_{flg} + 460\right)}{D_{tip}^{2}}$$

Equation 4.4-3, on page 4-23 of the handbook.

$U_{flg} = 85.625$ — Exit velocity of the flare gas, ft/sec.

Calculating Maximum Exit Velocity

Using the appropriate equation listed in Table 4.4-1. to determine the maximum exit velocity that would support a 98% destruction efficiency for this particular flare.

$$U_{max} := 3.28 \cdot 10^{0.00118 \cdot h_e + 0.908}$$

$U_{max} = 103.246$ Maximum Exit Velocity, ft/sec.

Since Uflg is less than maximum Umax, then 98% destruction level can be achieved.

Determining Emissions from the LFG Flare

Chapter 2.4 of AP-42 based the emission prediction on a function of the methane produce from the landfill. Thus, the flow rate of methane to the flow must be determined first.

$Q_{flare} := 1500 \cdot \frac{ft^3}{min}$ This is the maximum gas flow rate for the flare.

$C_{CH4} := 0.5$ Assumed that the gas vented to the flare has a methane content of 50%.

$Q_{CH4} := Q_{flare} \cdot C_{CH4}$

$Q_{CH4} = 750 \cdot \frac{ft^3}{min}$ Methane rate going to the flare.

$HV_{CH4} := 1013 \cdot \frac{BTU}{ft^3}$ Heating Value of Methane

$H_{flare} := Q_{CH4} \cdot HV_{CH4}$

$H_{flare} = 4.559 \cdot 10^7 \cdot \frac{BTU}{hr}$ Hourly Heat Input from the flare

Carbon Monoxide

$EF_{CO} := \frac{0.37 \cdot lb}{10^6 \cdot BTU}$ Emission factor for CO from AP-42, 13.5. "Industrial Flares".

$CO := EF_{CO} \cdot H_{flare}$

$CO = 16.866 \cdot \frac{lb}{hr}$ Maximum hourly CO rate.

$CO = 73.924 \cdot \frac{ton}{yr}$ Maximum annual CO rate

Oxides of Nitrogen

$EF_{NOx} := \frac{0.068 \cdot lb}{10^6 \cdot BTU}$ Emission factor for NO from AP-42, 13.5. "Industrial Flares".

$NO_x := EF_{NOx} \cdot H_{flare}$

$NO_x = 3.1 \cdot \frac{lb}{hr}$ Maximum hourly NOx rate.

$NO_x = 13.59 \cdot \frac{ton}{yr}$ Maximum annual NOx rate

Sulfur Dioxide

Sulfur Dioxide Emission were estimated using method outlined in Chapter 2.4 of AP-42.

$C_s := 183.4$ Cs is the default concentration listed in Charter 2.4 of AP-42 of the total reduced sulfur compounds (expressed in terms of ppmv),

$Q_S := \frac{Q_{CH4} \cdot C_s}{C_{CH4} \cdot 10^6}$ Equation 3 of Chapter 2.4

$T := (21 + 273) \cdot K$ Temperate of the landfill gas, Converted in Kelvin

$Q_S = 1.447 \cdot 10^5 \cdot \frac{ft^3}{yr}$ Volumetric flow of Total Reduced Sulfur.

$UM_S := \frac{Q_S \cdot 34 \cdot 1 \cdot atm}{\left(8.205 \cdot 10^{-5} \cdot m^3 \cdot \frac{atm}{mole \cdot K}\right) \cdot \left(1000 \cdot \frac{mole}{kg}\right) \cdot T}$ Equation 4 from Charter 2.4, AP-42. Calculating Uncontrolled mass emission rate of Total Reduce Sulfur on a mass basis.

$UM_S = 6.366 \cdot \frac{ton}{yr}$ Mass rate of Total Reduce sulfur.

$CM_{SO2} := UM_S \cdot 1 \cdot 2.0$ Equation 7 from Chapter 2.4 of AP-42. Calculating the controlled amass emission rate of sulfur dioxide from the flare. Assumed all of the total reduced sulfur is converted into sulfur dioxide. 2 = Ratio of the molecular weight of sulfur dioxide to the molecular weight of sulfur.

$CM_{SO2} = 2.905 \cdot \frac{lb}{hr}$ Hourly rate of Sulfur dioxide from the flare.

$CM_{SO2} = 12.731 \cdot \frac{ton}{yr}$ Annual rate of Sulfur dioxide from the flare. Assumed that the flow is maintained at the flare's maximum and operated continuously.

Particulate Matter

$EF_{PM} := \frac{17 \cdot lb}{10^6 \cdot ft^3}$ Emission factor from AP-42, Table 2.4-5, 11/98, in terms of MMCF of methane.

$PM := Q_{CH4} \cdot EF_{PM}$ Calculating the potential PM rate using the AP-42 factor and the maximum predicted generation rate of methane.

$PM = 0.765 \cdot \frac{lb}{hr}$ Maximum hourly PM rate.

$PM = 3.35 \cdot \frac{ton}{yr}$ Maximum annual PM rate

Volatile Organic Compounds (VOCs)

Since the flare is capable of achieving a destruction efficiency of at least 98%, then it is assumed that the potential VOC emissions from the flare would be the remain 2% of the NMOC. Carbon dioxide and methane are not classified as VOCs. Therefore, this two compounds were not include.

$DRE_{flare} := .98$ Minimum Destruction efficiency (DRE) of the flare.

The following calculations are outlined in AP-42 Chapter 2.4., which are to predict VOC emissions from the flare.

$C_{NMOC} := 593$ Default Concentration of NMOC listed in Chapter 2.4. (expressed in ppmv)

$MW_{NMOC} := 86.18$ Molecular Weight of NMOC, as hexane.

$$Q_{NMOC} := \frac{Q_{CH4} \cdot C_{NMOC}}{C_{CH4} \cdot 10^{6}}$$

Equation 3 of Chapter 2.4

$$UM_{NMOC} := \frac{Q_{NMOC} \cdot MW_{NMOC} \cdot 1 \cdot atm}{\left(8.205 \cdot 10^{-5} \cdot m^{3} \cdot \frac{atm}{mole \cdot K}\right) \cdot \left(1000 \cdot \frac{mole}{kg}\right) \cdot T}$$

Equation 4 from Charter 2.4, AP-42. Calculating Uncontrolled mass emission rate of NMOC on a mass basis.

$$CM_{NMOC} := UM_{NMOC} \cdot \left(1 - DRE_{flare}\right)$$

Calculating the control emission rate of NMOC from the flare.

$$CM_{NMOC} = 0.238 \cdot \frac{lb}{hr}$$

Maximum hourly NMOC (VOCs) rate.

$$CM_{NMOC} = 1.043 \cdot \frac{ton}{yr}$$

Maximum annual NMOC (VOCs) rate.

Hydrochloric Acid

The following calculations are outlined in AP-42 Chapter 2.4., which are to predict HCL emissions from the flare.

$C_{CL} := 74$ Concentration of Chloride listed in AP-42, Chapter 2.4 (expressed as CL in ppmv)

$MW_{CL} := 35.453$ Molecular Weight of NMOC, as hexane.

$$Q_{CL} := \frac{Q_{CH4} \cdot C_{CL}}{C_{CH4} \cdot 10^{6}}$$

$$UM_{CL} := \frac{Q_{CL} \cdot MW_{CL} \cdot 1 \cdot atm}{\left(8.205 \cdot 10^{-5} \cdot m^3 \cdot \frac{atm}{mole \cdot K}\right) \cdot \left(1000 \cdot \frac{mole}{kg}\right) \cdot T}$$

Equation 4 from Chapter 2.4, AP-42. Calculating Uncontrolled mass emission rate of total chlorides on a mass basis.

$$CM_{HCL} := UM_{CL} \cdot 1.03$$

Equation No. 10 from AP-42, Chapter 2.4. 1.03 is the ratio of the molecular weight of HCL to the molecular weight of chloride.

$$CM_{HCL} = 0.629 \cdot \frac{lb}{hr}$$

Maximum hourly HCL rate from the flare.

$$CM_{HCL} = 2.759 \cdot \frac{ton}{yr}$$

Maximum annual HCL rate from the flare.

Hydrogen Sulfide Loading in the LFG

45CSR10 establishes a maximum hydrogen sulfide grain loading in any waste gas stream being burned. Therefore, the following calculations will determine the H2S loading in the landfill gas stream going to the flare.

$$grain := \frac{1}{7000} \cdot lb$$

This equation creates grains as a mass unit.

$$UM_{H2S} := UM_S \cdot 1.0625$$

Assuming all of the total reduced sulfur in the landfill gas is hydrogen sulfide. Thus, mass balance is used to determine the mass rate of hydrogen sulfide in the landfill gas. 1.0626 is the ratio of the molecular weight of hydrogen sulfide to the molecular weight of sulfur.

$$CON_{H2S} := \frac{UM_{H2S}}{1500 \cdot \frac{ft^3}{min}}$$

Converting this mass rate into a volume basis by using the maximum flow rating of the flare.

$$CON_{H2S} = 12.002 \cdot \frac{grain}{100 \cdot ft^3}$$

Hydrogen sulfide loading, expressed in terms of grains per 100 cubic feet of carrier gas. Standard from 45CSR10-5.1 is 50 grains of H2S per 100 cubic feet of gas. Thus, this landfill gas complies with 45CSR10-5.1.